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ELECTRIC MILK PASTEURIZERS FOR FARM DAIRIES

An Address By
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Many diseases of humans are milk-borne. Such disease outbreaks reported by state and local health authorities as having occurred in the United States include typhoid fever, scarlet fever, septic sore throat, food poisoning, paratyphoid fever, undulant fever, dysentery, diphtheria, and others. According to health authorities, proper pasteurization of milk can and does prevent their transmission and all milk-borne disease is preventable. Further, no raw milk can be guaranteed as safe.

Based upon reports for the 10-year period, 1932 to 1941, the estimated average annual economic loss from mild-borne diseases in the United States amounts to more than $2,800,000. Of these, undulant fever ranks first with about $2,150,000; typhoid fever second with $400,000; and scarlet fever and septic sore throat third with $200,000. The number of undulant fever cases and deaths reported in the United States by years since 1932 follow:

Undulant Fever

Year	Cases	Deaths	Year	Cases	Deaths
1932	1,502	62	1939	3,501	121
1933	1,788	72	1940	3,310	116
1934	2,017	65	1941	3,484	71
1935	2,008	98	1942	3,228	76
1936	2,095	107	1943	3,734	77
1937	2,675	82	1944	4,436	80
1938	4,379	116	1945	5,049	101

Since these diseases can be prevented and the economic losses avoided through the proper pasteurization of milk, the Rural Electrification Administration has stressed for the past several years the development of pasteurization equipment suited for use in the farm home and by the small milk retailer. Definite progress has been made. Manufacturers, researchers, and others have participated and much credit is due all of them. Several small milk pasteurizers are now on the market and others will be in the near future. Still others are in the model or experimental stage.

Before examining specific units, it might be well to review briefly the history of pasteurization and define the process. As commonly thought, the process of milk pasteurization did not originate with Louis Pasteur. He, however, did introduce the method and used it for heating beer and

wine so as to prevent souring. In 1873 Jacobi of New York City recommended that milk for infant feeding be boiled in the bottles. As far as is known, he was the first to advocate the heating of cows' milk. Twenty years later, 1893, Nathan Straus, New York City, was the first to sell sterilized milk. In short order, many others followed suit. Continuous-flow milk heating equipment was developed between 1890 - 1905 using temperatures from 158 to 165 F. This was not too satisfactory as controls were inaccurate and holding times indefinite. In 1906, Rosenau found that he could destroy the most heat-resistant, milk-borne pathogen at 140 F in 20 minutes. Because of his work and the corroboration of it by other investigators, low-temperature pasteurization was generally accepted by health authorities. Great improvements were made in the commercial equipment because of the development of controls and safety devices. These improvements led to the acceptance of high-temperature, short-time pasteurization by health authorities. These two methods are defined by the Milk Ordinance and Code as follows: "Pasteurization is the heating of every particle of milk or milk product to at least 143 F and holding at this temperature for at least 30 minutes, or to at least 160 F and holding for at least 15 seconds, in approved and properly operated equipment."

Pasteurized milk is available in most of the larger communities. In 1936 the United States Public Health Service reported pasteurized milk available in 42 percent of the communities, having a population of 1,000 to 2,500, with 24.5 percent of the milk pasteurized. Undoubtedly, there was a lesser percentage of pasteurized milk available and used in the still smaller communities and most milk producers used raw milk. For these smaller communities and individuals pasteurization equipment, which is low in initial cost, yet effective, must be provided. What has been done to meet this need? Let us take a look.

Milk Pasteurizers for Small Retailers

Resistance-Type Batch Pasteurizer

Research work was begun in 1931 on a 12-gallon electric resistance-type batch pasteurizer by the National Rural Electric Project in cooperation with the University of Maryland. Results of these investigations were published in two progress reports by H. E. Besley and A. V. Krewatch respectively who carried on this research. This project was abandoned in 1933 and reopened in 1937 by Maryland Agricultural Experiment Station with Professors George J. Burkhardt, C. W. England, and A. P. Wiedemer continuing the work.

The steel vat of the model pasteurizer is lined with synthetic rubber. The inside dimensions are about 24" x $13\frac{1}{2}$" x $10\frac{1}{2}$". The two electrodes are of graphatized carbon, 3/4" x 12" x 10" and hook over the rim of the vat. The resistance of milk to the flow of alternating electric current is used as the heating means. It operates on 230 v., a.c., and the maximum current demand is 31 amperes.

A milk agitator mounted on the cover is driven by a small electric motor located under the vat. A mercury column thermostat is used which accurately regulates the temperature of the milk within $\frac{1}{2}$ F.

When the milk reaches 143 F, a self-starting electric clock is started by means of a sensitive control relay and continues to run for 30 minutes. An alarm signals the end of pasteurization.

Safety features are embodied in the design to prevent accidental electric shock to the operator. When the cover is lifted the circuit is automatically broken. The drain is located at the neutral point of the 220 volt circuit so that contact with milk leaking or flowing from the drain while the current is on will not cause shock. A heavy ground is supplied.

For a 12-gallon batch the total amount of energy used ranged from 0.3 kwh per gallon with a starting temperature of 38 F, to 0.16 kwh per gallon with a starting temperature of 90 F. Many months of experience with this unit in more or less regular operation indicated that the unit is safe, workable, efficient, and very quiet in operation. Complete details of this unit were published in the March 1941 issue of Agricultural Engineering.

In June of this year, A. H. Baxter, Northeastern Engineering, Inc., Manchester, New Hampshire, was looking around to locate new items for his company to develop and manufacture. Rural Electrification Administration advised him regarding the research on the Maryland pasteurizer and referred him to Professor Burkhardt. This company is building several models which will be ready soon for testing by Maryland University. Although the fundamental principles of the original model have been retained, many refinements have been incorporated in the model built by Northeastern Engineering, Inc.

A solid porcelain tank is encased in a modernistic cabinet, finished in acid-resistant enamel. The agitator and thermostat are built into the cover. The tank slopes to a stainless steel drain valve in the center, and doors in the front allow access for a standard milk can. The splash-proof steel control panel for wall mounting is also finished in acid-resistant enamel. It houses the circuit breakers, relays, and synchronous motor-driven timer. On its front are indicating lights for 220 v. power on; for 110 v. agitator motor on; and a light or bell to show the end of pasteurization.

Heavy molded rubber cord sets permit interconnection between the wall control panel and the pasteurizer cabinet. Interlock switches on doors and covers eliminate all electric shock hazard.

High-Temperature, Short-Time Pasteurizer

During the late thirties Maurice W. Nixon, then stationed at Cornell University, developed an experimental model high-temperature, short-time pasteurizer. It was designed so that all adjustable devices, including temperature regulators and milk and water flow regulators, could be adjusted, tested and sealed by the Department of Health, thereby eliminating all manual adjustments. Except for supplying and removing the milk, the operation of this pasteurizer is entirely automatic.

In operation, hot water at about 163 F from an electric water heater is circulated by a pump through booster heaters having a total capacity of 11 kw, through a two-stage tubular milk-cooler unit and returned to the heater. The booster heater maintains the water at 172.5 to 174 F.

The milk is pumped from a milk sump to a supply tank from which it flows by gravity through a heat exchanger where the milk absorbs from 16 to 24 F of heat from the milk already pasteurized. This pre-heated milk then flows over the hot water tubular surface heater, is heated to 163 F, collected in a trough, and fed into an inverted siphon which serves as a 15-second holding chamber. After flowing through the heat exchanger, the milk is discharged to be cooled for storage. If the milk does not reach 163 F, it is automatically diverted back to the sump.

The capacity of the pasteurizer, in gallons per hour, is determined by the volume of water available, the temperature drop which may be compensated for in the booster heaters, and the temperature of the raw milk. With an 82-gallon water heater, the hot water flowing at the rate of 7 to 8 gallons per minute, and the booster compensating for a temperature drop of 11.7 F, the capacity was 23 gallons per hour of 45 F milk and 60 gallons per hour of 82 F milk. The electric energy consumption for this unit ranged from 1/3 to slightly over 1/2 kwh per gallon of milk pasteurized plus stand-by water heater losses. This pasteurizer is described in detail in the July 1941 issue of Agricultural Engineering.

Although this small unit has not been developed further for commercial production, definite possibilities lie in this method of pasteurization. Mr. Nixon showed that a high-temperature, short-time pasteurizer can be built at a nominal cost and operated successfully.

In-the-Bottle Pasteurizer

Two experimental in-the-bottle pasteurizers were developed prior to 1941 by D. E. Blandy, at that time with New York Power and Light Corporation, Albany, New York. Their capacities were 4 cases or 48 quarts and 8 cases or 96 quarts.

The July 1941 issue of Agricultural Engineering contains the following statement on this unit:

> "The principle involved in the method consists of transferring heat as quickly as possible from a body of water held at 145 F to the bottled raw milk. The bottled milk is held in the vat for an hour and then cooled, still bottled.
>
> "The equipment consists of a hot water tank with water pump, immersion-type electric heaters and the necessary thermostats to control the temperature of the water bath, and indicating and a recording thermometer, and racks to support the bottle cases. It was necessary to use a new thin-wall, over-size glass milk bottle. Convection currents are set up in this bottle, making heating about twice as rapid as in the standard bottle. Bottle caps with paper inserts seal the bottle.

> "The heating period of about one-half hour is followed by a half-hour holding period, both of which are recorded on a graphic thermometer chart. After the milk has been held, the pump is stopped and the vat opened to remove the bottles in the wire crates. These are set in the air for five minutes or so, after which they are immersed in a cold circulating water bath and cooled to the desired temperature for storage. A milk cooler tank with special platform and pump was used for this purpose."

It is reported that this pasteurizer was manufactured by Emil Steinhorst and Sons, Utica, New York. Production ceased because of the war but it is believed by interested parties that production will be resumed at an early date.

Batch Pasteurizers

Prior to the war, Oakes & Burger Co., Inc., Cattaraugus, New York, built experimental batch pasteurizers of 10-, 20-, and 30-gallon capacity. The war interfered with the further development and quantity production of this equipment. In addition to the previously mentioned sizes, consideration is now being given to a unit of 5-gallon capacity or less and perhaps a 15-gallon size.

The round milk container of this pasteurizer is constructed of 20-gauge stainless steel with all joints welded and polished. It is surrounded with a water jacket constructed of plate steel with the inner surface treated to retard rust. The height and diameter of the pasteurizer vary with the capacity. It is insulated with asbestos sheeting covered with light gauge galvanized steel. The cover is made of stainless steel with openings for the indicating and recording thermometers. It also has an opening to accomodate a standard milk can strainer which has its own cover, eliminating the need of removing the complete cover while filling. An agitator, which is removable for cleaning, is mounted on top of the tank and is operated by a 1/30 hp, 110 v., a.c., 60 cycle motor.

Water at 160 F is supplied by an electric water heater. The size depends upon the capacity of the pasteurizer. A water-circulating pump, driven by a 1/30 hp, 110 v., a.c., 60 cycle motor, circulated the hot water through the water jacket of the pasteurizer.

When the milk reaches 143 F, the hot water motor stops, shutting off further circulation, and a thermostat operates a solenoid valve, permitting the hot water to run out of the water jacket. This prevents further heating and it is claimed that the pasteurization temperature is maintained for 30 minutes.

It is reported that a 20-gallon pasteurizer installed on the farm of Edward H. Hickman, Eden, New York, has given complete satisfaction. He generally pasteurizes twice a day. The equipment is so arranged that after the milk is pasteurized he circulates cold water from the milk cooler through the water jacket. Average energy consumption is approximately 0.6 kwh per gallon of milk pasteurized.

Another 10-gallon batch pasteurizer was designed and built for use on the experimental farm of Republic Steel Corporation, Cleveland, Ohio, by Earl S. Anderson and Tom Long to provide pasteurized milk for the families living on the farm and visitors. After analyzing a number of commercial units of larger size and reviewing the requirements of pasteurization, they designed a pasteurizer to be as simple as possible.

Fundamentally, it is designed around a 10-gallon milk can, which serves as a holding vessel throughout the pasteurizing and cooling operation. An outer round jacket for water, which surrounds the milk can, is encased in a cabinet approximately 2' x 3' x 3'. Holes are provided near the upper edge of the round inner shell through which both hot and cold water are sprayed against the can.

A 6 kw electric immersion heater operating on 230 v., a.c., 60 cycles, is installed in the pasteurizer.

After a can of milk is placed in the pasteurizer, approximately 8 gallons of hot water at about 140 F from an electric water heater are poured into the surrounding water jacket. It requires approximately 30 minutes for the 6 kw heater to bring the milk up to the 143 F pasteurization temperature. A pump, powered by a 1/3 hp motor, circulates the hot water around the can. The agitator, driven by a $\frac{1}{4}$ hp motor through a gear reduction drive, and the tube of the recording thermometer are inserted in the milk through holes provided in the special can lid. Smaller motors could be used but were not available. When the 30-minute pasteurization process is over, a bell rings.

The heating element is turned off manually and the hot water drained. A 1/3 hp motor starts a pump and cold water from a milk cooler is circulated around the can. It requires about 20 minutes to cool the milk from 143 to 50 F after which the milk is stored in the milk cooler.

No energy studies have been made on this pasteurizer. Changes, such as using smaller and fewer motors and pumps, are being considered. Besides being simple in design and operation, this pasteurizer has a minimum number of parts to wash and sterilize. This is an important factor in a one-man dairy.

Radiant Energy Milk Pasteurizers

Dr. Matthew Luckiesh, Director, Lighting Research Laboratory, General Electric Company, Cleveland, Ohio, in his recent book, "Applications of Germicidal, Erythemal, and Infra-red Energy," writes as follows regarding the use of germicidal sources in treating highly absorbing liquids:

> "However, it is justifiable to immerse such sources in highly absorbing liquids as indicated in the figure. In the cross-section A, two different groupings of germicidal sources are shown in C and D. The liquid L enters through I and after meandering it flows out at O at an appropriate rate, depending upon its absorption-coefficient and the kind of micro-organisms

to be killed. Inasmuch as the liquid is not under pressure, it appears practicable to use rubber sleeves S as shown in the cross-section B. Although each germicidal source is of low wattage, many of them will represent a total wattage that may be rather high. Obviously the heating effect upon the liquid must be taken into account.

"Milk in a very thin layer is highly absorbing. Nevertheless, many years ago experiments were made with quartz mercury-arcs in disinfecting very thin films. In one case this film was gathered on the edge of a revolving disk and was wiped off and collected after exposure to ultra-violet energy. Inasmuch as a 30-watt germicidal source is nearly as effective in killing micro-organisms as a 300-watt quartz mercury-arc, it is possible that milk might be successfully treated in a device such as that illustrated. Ozone imparts an undesirable taste to the milk. Therefore, the air in the milk or in contact with it might have to be eliminated or at least reduced."

Cold-ray pasteurization of milk in Germany was reported by C. O. Ball on behalf of U. S. Technical Industrial Intelligence Sub-Committee. This pasteurizer is installed in the plant of Hansa Meierei Facherberger Allee, Lubek, which produces evaporated milk and milk powder. The unit consists essentially of a spiral quartz tube, approximately 0.4 inch in diameter, said to be 360 feet long, and 8 mercury vapor tubes supplying ultra-violet rays.

The milk tube, coiled to a diameter of about 13 inches, is mounted in a horizontal position in a roughly constructed sheet metal cylinder about 24 inches in diameter and 70 inches long having wooden ends. Four mercury vapor tubes having an outside diameter of about 1/3 inch are placed on the inside of the coil, about $5\frac{1}{2}$ inches apart, and 4 additional ones on the outside, about 13 inches apart. These tubes are about 4 inches longer than the coil enclosure so that they can be supported horizontally through holes in the ends.

Connection at each end of the quartz tube milk coil is made by rubber tubing. A rotary pump forces the milk through the coil at the rate of 53 gallons per hour and it is exposed for $1\frac{1}{4}$ minutes.

A progress report, undated, by Lembke, Rickert, Thomsen, and Christopherson, Preuszischen Versuchs-und Porschungsanstalt fur Milchwirtschaft, Kiel, makes the following statement in regard to studies of the ultra-violet ray pasteurizer:

"Results: Almost complete sterilization of the milk was attained, whereby the milk would keep approximately 24 hours longer. Both spore-forming proteolytic bacteria and all pathogenic organisms could be positively destroyed. ... The taste change can be regarded as insignificant. Enrichment with vitamin D proceeds simultaneously."

The results, however, are not to be considered to be sufficiently definite and consistent to justify a statement that the efficiency of the ultra-violet method of pasteurization has been proved. A procedure which could be utilized with confidence in pasteurizing milk by this means has not been worked out. The most serious obstacle lies in the failure to provide a means of assuming that every particle of milk is in contact with the walls of the exposed quartz tube for a sufficient length of time to enable the rays to destroy the dangerous micro-organisms contained therein. This objective can be attained by allowing a sufficient length of time to ensure the necessary exposure to all particles of milk, or by increasing the turbulence in the stream of milk while passing through the tubing.

It would seem that a large amount of fundamental work remains to be done in developing a means of providing positive control of the factors discussed.

Home Pasteurizers

Batch Pasteurizers

A home pasteurizer electrically operated is manufactured by Guard-it Manufacturing Company, 615 North Aberdeen Street, Chicago, Illinois.

This unit stands approximately 21 inches high and has an outside diameter of about 12 inches. It consists of an outer rust-resistant metal water container, equipped with handles and coated with baked enamel, a cover with built-in stainless steel agitator, operated with a solenoid type motor, and an inner steel, tin hot dipped, two-gallon milk container. A 1250 watt, 110 - 120 v., a.c., 60 cycle immersion-type heater is installed in the base.

When pasteurizing milk, the water tank is filled with 9 quarts of water. The timer is set for about 30 minutes and the unit plugged into and outlet. When the water is heated to a temperature of 145 to 149 F, the thermostat setting, the lower of two lights glows on the control panel. If warm water is used, less time will be required. The pail, containing the milk, is then set in the water bath. This container is held by a strap hanger, supported on rubber gaskets. The cover assembly is next put in place and the motor-agitator plugged into the front panel outlet. The time switch is set for one hour. If the milk is below 60 F, an extra 15 minutes should be allowed for heating the milk. The termostat automatically turns the heater on and off to maintain the water and milk at the required temperature. When the upper lamp lights, it indicates the end of the pasteurization process.

It is claimed by the manufacturer that the up and down action of the agitator not only causes the milk to circulate but this action is also transmitted to the sorrounding water bath, thus insuring an even temperature distribution both in the milk and the water.

If a pressure water supply is available, cold water can be circulated around the milk container by means of a hose connection. An overflow is provided. Operation of the agitator for about 20 minutes will insure still faster cooling. Or, the milk container may be removed immediately after pasteurization and placed in a milk cooler for storage. Again, the agitator should be used to speed up the cooling.

Another electric batch pasteurizer is made by Waters Conley Company, Rochester, Minnesota, and marketed by Sears, Roebuck and Co., Chicago, Illinois.

The pasteurizer consists of a base having a 300 watt, 110 - 120 v., a.c., 50 or 60 cycle heating element with thermostat placed in the bottom of a barrel which serves as a housing and flue to distribute the heat around a 1-gallon milk bucket. Both housing and bucket are made of drawn aluminum. The housing is coated with baked lacquer. The lid of the bucket overlaps the rim so as to shed water when cooling the pasteurized milk. The thermostat is spring-mounted to insure good contact with the bottom of the bucket. A thermostatically controlled timer does not operate until the milk has been heated to the pasteurization temperature. A buzzer operates when the timer returns to the "off" position.

When pasteurizing milk, the timer knob is turned to the right as far as possible, the unit plugged into an outlet, and the operation is automatic. When the milk reaches the proper temperature, the heater is turned off and the timer starts operating. If the temperature of the milk drops below 143 F, the thermostat turns on the heater and stops the timer until it is again up to temperature. At the end of the 30-minute pasteurization period, the current is cut off from the heater and a buzzer sounds until the pasteurizer is disconnected.

With a full gallon of milk at 50 F, approximately 1 hour and 15 minutes are required to complete a pasteurization cycle. Smaller quantities may be pasteurized, although less than a quart may heat too rapidly.

It is claimed by the manufacturer that, by locating the heating unit near the edge of the milk container, convection currents are set up in the milk, thus heating it slowly and preventing scorching or localized overheating. The approval of Underwriters' Laboratories, Inc., is being requested.

In-the-Bottle Pasteurizer

The pasteurizer, developed by H. E. Wright Company, 32 Cambridge Street, Charlestown, Massachusetts, is an in-the-bottle household unit, about 24" x 14" x 10" in size and weighs 24 pounds empty. Its capacity is 9 square quart milk bottles, or 7 round quart milk bottles, or 7 quart fruit jars. In each case an extra bottle filled with water is used for immersing a thermostat which operates at 143 F and is fastened to the cover.

The outer shell of the pasteurizer is made of rust-proof metal and finished with baked enamel. The inner shell is made of either cast aluminum or copper and the lid of stainless steel. It is insulated on all sides and

bottom with corrugated asbestos sheets. The 1,500 watt immersion-type heating element operates on 115 v., a.c., 60 cycles. A second thermostat is located in the bottom of the tank which controls the water bath at 147 to 149 F.

The unit is practically automatic in operation. When pasteurizing it is connected to the pressure water system by means of a hose. The capped bottles of milk are then placed in the tank. A little air space should be left in each bottle to allow for expansion of the milk. The cover is put on with the thermostat placed in the bottle of water. The thermostat cord is connected to the control panel. The switch is put in the "on" position and the timer is set in the "off" position. A magnetic valve opens and the water flows into the tank. The depth is controlled by an overflow pipe which can be removed for draining and cleaning the tank. Different lengths of overflow pipe are provided for various heights of bottles. After the tank is filled with water, the timer is set in the "start" position. This automatically cuts off the water flow and turns on the heater. It requires about 50 minutes to bring the temperature in the water-filled bottle to 143 F. Then the timer, which is set for a 30-minute pasteurization period, starts. It stops if the temperature in the bottle falls below 143 F. When pasteurization is completed, the magnetic valve opens and allows cold tap water to circulate around the bottles. Cooling requires about 20 minutes and the flow of water is stopped by turning the switch to the "off" position. The milk is then ready for use or storage.

This company plans to build a similar pasteurizer for the milk retailer with the same controls, operating on 230 v., a.c., 60 cycles, with a 6 kw immersion heater and having a capacity of 29 square quart milk bottles, or 23 round quart milk bottles, or 23 quart fruit jars.

In addition to the cases listed, research was carried on at the University of Texas. High voltage and low amperage were used. The results were not too successful. High-frequency pasteurization investigations were contemplated but the war prevented the securing of the necessary apparatus. Two state agricultural colleges expect to do research in this field in the near future. It is also reported that other manufacturers are engaged in investigating the possibilities of producing small pasteurizers.

It has been most gratifying to report the progress made in the research and development of electric pasteurizers. As all milk-borne diseases can be controlled by proper pasteurization, it is important that every effort be made to develop and produce effective electric equipment for home use and for small milk retailers, as demanded by the public, and thus prevent these diseases, deaths, and the economic loss suffered by the people of our country.

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